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LIME-SULPHUR MIXTURES FOR THE SUMMER SPRAYING OF ORCHARDS.

BY

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LIME-SULPHUR MIXTURES FOR THE SUMMER SPRAYING OF ORCHARDS.^a

INTRODUCTION.

During the summer of 1907 the Department of Agriculture conducted experiments in Arkansas and Missouri with self-boiled and unboiled lime-sulphur mixtures for the control of apple and peach diseases, the object being to develop, if possible, a fungicide that could be used on growing trees, particularly peach, without the injury commonly following applications of Bordeaux mixture. The results of these experiments, which were published in Circular 1, Bureau of Plant Industry, were so encouraging that more extensive experiments were planned for the following year.

In 1908 experiments were conducted under the writer's supervision in Georgia, Arkansas, Nebraska, and Illinois, and in New Hampshire in cooperation with the New Hampshire Agricultural Experiment Station, using self-boiled, home-boiled, and factory-boiled or commercial lime-sulphur preparations, as well as some other possible fungicides. The work in Georgia was carried out by Mr. T. W. Ayres, and that in Arkansas by Mr. James B. Rorer. The writer personally looked after the work in Illinois and Nebraska, assisted at the latter point by Mr. George E. Merrill. Dr. Charles Brooks conducted the New Hampshire work, the results of which are to be published by him in a forthcoming report of the New Hampshire Agricultural Experiment Station. It is not the object of this paper to give all the details of these experiments or to report upon all of the substances tested, but rather to discuss those features that will be of most interest to orchardists.

^a This paper is a report of the second season's experiments with lime-sulphur preparations for summer spraying, together with additional experiments with other sulphur compounds. The work was carried out more thoroughly on both the peach and the apple and extended to include the cherry. The experiments resulted in some modifications in the method of making the mixtures for the peach and for Japanese plums, but on the whole they were very encouraging for further experiments and for widespread use in the orchard where Bordeaux mixture is found objectionable.—B. T. GALLOWAY, *Physiologist and Pathologist, and Chief of Bureau.*

LIME-SULPHUR SPRAYS.

There are now three lime-sulphur preparations which have considerable value as fungicides—home-boiled lime-sulphur wash, factory-boiled lime-sulphur solution, and self-boiled lime-sulphur mixture.

HOME-BOILED LIME-SULPHUR WASH.

The home-boiled lime-sulphur wash is the regular wash for the San Jose scale which has been used as an insecticide and as a fungicide for a number of years. Various formulæ are used in its preparation, but the following seems to meet all requirements: Lime, 20 pounds; sulphur, 15 pounds; and water, 50 gallons. The lime, the sulphur, and about half of the water are boiled together for about forty-five minutes in a kettle over a fire or in a barrel or other suitable tank with steam. After straining and diluting to 50 gallons the wash is ready for application to the trees. Practically all of the sulphur goes into solution and combines with the lime in the form of monosulphid, polysulphid, and thiosulphate.

For spraying trees in the dormant state this wash may be substituted for Bordeaux mixture as a fungicide, and it is a common practice in some sections to use it for the peach leaf-curl. Being both an insecticide and a fungicide, it makes a good combination treatment for the San Jose scale and leaf-curl. It is injurious to foliage, however, and can not be safely used as a summer spray unless greatly diluted, and then not effectively on the peach.

FACTORY-BOILED OR COMMERCIAL LIME-SULPHUR SOLUTION.

The factory-boiled lime-sulphur solution is a concentrated solution of practically the same composition as the homemade wash and is placed on the market as a substitute for the latter by several reputable firms. The home-boiled wash is troublesome to make and does not keep well owing to crystallization of the sulphur, so that the prepared wash, which keeps indefinitely and is ready to use when received, requiring only dilution with water, is becoming popular. There is some variation in the strength of the solutions made by different firms, but they usually contain $2\frac{1}{2}$ to 3 pounds of sulphur to each gallon and register 25° to 32° on the Baumé hydrometer scale.

For insects and diseases on dormant trees a strength of 1 gallon of the solution to 9 to 11 gallons of water is the usual recommendation, and this strength appears to give satisfactory results. For summer use, however, the solution requires a very much greater dilution and it can not be safely used at any effective strength on peach trees in foliage. According to our experience during last season a strength of 1 to 25 can be used on apples without any serious injury, but a stronger wash appears to be unsafe.

During the past two years commercial lime-sulphur has been rather extensively tested as a summer spray by investigators and fruit growers in different parts of the country, and the results have been somewhat conflicting. A report of experiments conducted by Mr. R. Kent Beattie,^a of the Washington Agricultural Experiment Station, shows that a strength of 1 gallon of the solution to 11 gallons of water caused no injury to the fruit or foliage of Ben Davis and Jonathan apple trees and that it controlled apple scab. In the experiments reported later in this paper a strength of 1 to 20 injured apple foliage, and it would appear to be entirely unsafe to use it stronger than 1 to 25. Even the latter strength can not be recommended with full confidence.

SELF-BOILED LIME-SULPHUR MIXTURE.

The self-boiled lime-sulphur mixture is a combination of lime and sulphur boiled with only the heat of slaking lime and is primarily intended for summer spraying as a substitute for Bordeaux mixture where the latter is injurious to foliage or fruit. For most purposes Bordeaux mixture is the better fungicide and should be used except when likely to injure the plants to be treated. Peach foliage is so susceptible to spray injury that Bordeaux mixture can not be safely used as a summer spray on peach trees; neither can the sulphur sprays which contain any considerable quantity of sulphids in solution. The self-boiled lime-sulphur mixture, however, when prepared as a mechanical mixture of lime and sulphur with only a small percentage of the sulphur in solution, is not injurious to peach foliage and in our experiments for two years past has proved to be a good fungicide. It may also prove useful in spraying some varieties of apples, like the Ben Davis and Jonathan, which are often seriously injured by applications of Bordeaux mixture.

The mixture that appeared to be the most satisfactory in our experiments was composed of 10 pounds of lime and 10 pounds of sulphur to 50 gallons of water. However, 8 pounds of lime and 8 pounds of sulphur to 50 gallons of water may prove to be sufficient. This strength of mixture was not tried, but a 6-6-50 formula used on peach and cherry trees gave good results, though not quite so good as the stronger wash.

The mixture can best be prepared in rather large quantities—say 20 pounds, or even 40 pounds at a time—so as to get enough heat to produce a violent boiling for a few minutes. Place the lime in a barrel and pour on enough water (about 3 gallons to 20 pounds) to start it slaking and to keep the sulphur off the bottom of the barrel. Then add the sulphur, which should first be worked through a sieve

^a The Western Fruit Grower, January, 1909, p. 6.

to break up the lumps, and finally enough water to slake the lime into a paste. Considerable stirring is necessary to prevent caking on the bottom. After the violent boiling which accompanies the slaking of the lime is over, the mixture should be diluted ready for spraying, or at least enough cold water added to stop the cooking. Five to fifteen minutes are required for the process, according to whether the lime is quick acting or sluggish. The intense heat seems to break up the particles of sulphur into about the physical condition of precipitated sulphur, and the violent boiling makes a good mechanical mixture of the lime and sulphur. Only a small percentage of the sulphur—enough to improve the adhesiveness of the mixture—goes into solution, but if the hot mass is allowed to stand as a thick paste the sulphur continues to unite with the lime, and at the end of thirty or forty minutes enough of the reddish liquid is produced to burn peach foliage and even apple foliage in some cases. Hence the necessity for cooling the mixture as soon as the lime is well slaked. The finely divided sulphur in mechanical mixture with the lime is depended upon for the fungicidal action rather than the sulphids in solution, the latter being harmful to foliage except in very dilute form.

The mixture should be strained through a sieve of 20 meshes to the inch in order to remove the coarse particles of lime, but all the sulphur should be worked through the strainer.

The amount of water required to make the best mixture depends largely upon the lime. Some grades of lime respond quickly and take a large quantity of water, while others heat up slowly and are easily “drowned” if too much water is added at once. Hot water may be used to good advantage in preparing the mixture with sluggish lime, but with quick-acting lime hot water is not necessary and is more likely to bring too much of the sulphur into solution. If desired, the mixture may be kept for a week or more without deterioration, but should be thoroughly stirred before using.

In applying the self-boiled lime-sulphur mixture the spraying outfit should be equipped with a good agitator. The mixture settles to the bottom of the tank, and unless kept thoroughly agitated can not be evenly applied. For a power sprayer the propeller type of agitator is most suitable. The agitator of the ordinary barrel sprayer is not usually adequate and when used should be supplemented with frequent hand agitation.

Arsenate of lead or Paris green may be used in the self-boiled mixture for spraying apples, but since Paris green is injurious to the peach it is unsafe to use it with the mixture in spraying this fruit during the growing period. In one of our experiments at Marshallville, Ga., arsenate of lead was used with the self-boiled wash at the rate of 2

pounds to 50 gallons, and both fruit and foliage of the peach were somewhat injured. It is possible, however, that under certain conditions the two substances might be used together on the peach without injury, as indicated by reports received from one of our correspondents; but according to the data at hand the combination can not be recommended for the peach.

PEACH FOLIAGE INJURY TEST.

Before the chief experiments of the season were undertaken a series of foliage tests was made at Marshallville, Ga., to determine the effect of several different mixtures on peach leaves. The Red River and the Elberta varieties were used and the trees were sprayed about two weeks after the petals had fallen.

With prepared or factory-boiled lime-sulphur solution at the rate of 1 gallon to 30 gallons of water, injury to the foliage began to show three days after the application was made, and a week later a large percentage of the leaves had dropped. At a strength of 1 to 50, and even at 1 to 75, this solution caused severe injury, resulting in a partial defoliation of the trees. A strength of 1 to 100 also injured the foliage considerably and caused a few leaves to drop. A homemade wash boiled over a fire forty-five minutes and diluted so as to contain only 1 pound of lime and three-fourths of a pound of sulphur to 50 gallons of water slightly injured the leaves, causing some shot-holing. It would seem, therefore, that there is little hope for boiled lime-sulphur solution as a fungicide for peach trees in foliage. On account of the injury, these plots were not carried through the season to determine the fungicidal effect of the boiled wash.

In the experiments made during 1907 the self-boiled lime-sulphur mixture made of 15 pounds of lime and 10 pounds of sulphur to 50 gallons of water did not injure peach foliage on trees sprayed as many as five times. This was rather surprising, and the results of the work were published with some misgivings. The first work of the following season, therefore, was to determine what injury, if any, would be produced by the mixture under the most severe test. An excellent grade of lime was secured and hot water used to slake it. It was soon proved that by using the minimum amount of water required to slake the lime and letting the hot mass of lime and sulphur stand for thirty or forty minutes, a large percentage of the sulphur went into solution, combining with the lime to form sulphids and thiosulphate as in the boiled wash. The mixture gradually became thinner and a reddish liquid bubbled up from the bottom. It seems that the top layer holds in the heat sufficiently to continue the cooking for an hour after the lime is slaked. The mixture made in this manner injured the leaves badly, causing considerable defoliation; but when

cold water was added to stop the cooking as soon as the violent boiling ceased, no injury resulted from its use on peach foliage. Further tests showed that the mixture could be just as effectively made with cold water, provided the lime was good, and when so made there was less danger of bringing an injurious amount of sulphur into solution.

Mixtures prepared as outlined above were used on the Elberta and the Red River peaches in Georgia, on the Elberta in Arkansas, and on the Elberta, the Carman, the Waddell, and the Picquet's Late varieties in Illinois without injury to the foliage of the trees treated.

PEACH SCAB AND BROWN-ROT EXPERIMENTS.

EXPERIMENT IN GEORGIA.

A block of Red River peaches in the orchard of Mr. S. H. Rumph, at Marshallville, Ga., was chosen for an experiment in the control of peach scab or black-spot (*Cladosporium carpophilum* Thüm.) and brown-rot (*Sclerotinia fructigena* (Pers.) Schröt.). The orchard was about 8 years old, and in recent years the fruit had been so badly injured by both scab and brown-rot that Mr. Rumph declared his intention to dig up the trees and dispense with this variety entirely.

Plots of 20 trees each were sprayed on April 14, May 8, and May 18 with self-boiled lime-sulphur mixture made of 15 pounds of lime and 10 pounds of sulphur to 50 gallons of water, and a check plot of the same number of trees was left untreated. The first spraying date was about a month after the petals had fallen, and the last about three weeks before the bulk of the fruit was picked.

Hot water was used in preparing the mixture for plot 1 and cold water for plot 18. In each case the mixture was diluted immediately after the lime had finished slaking, so as to arrest the cooking. The hot-water mixture slightly scorched some of the leaves around the margin but not to any injurious extent, and the cold-water mixture caused no scorching whatever.

From June 1 to June 15 the crop of 5 average trees in each plot, including the check plot, was picked and sorted for brown-rot and scab. The results are shown in the following table:

TABLE I.—Results of experiments for the control of peach scab and brown-rot, Marshallville, Ga., 1908.

Plot.	Treatment.	Peaches affected with brown-rot.	Peaches scabbed.	Peaches badly scabbed.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Lime-sulphur mixture (15-10-50), hot water.....	10.56	20.75	0.80
18	Lime-sulphur mixture (15-10-50), cold water.....	12.22	16.60	.62
36	Check—no treatment.....	36.98	93.63	42.12

In the early part of the season the weather was very wet, so that the fruit became badly infected with scab, but later it turned dry and the brown-rot was unusually light for this variety.

As shown in Table I, nearly 37 per cent of the crop on the unsprayed trees rotted, while only about 10 per cent to 12 per cent of the crop on the sprayed plots was affected, a difference of about 25 per cent in favor of the treatment. The skin of the peach is so easily broken by insects and other agencies that it seems almost impossible to hold the disease down to less than 10 per cent of the crop in sections where it is serious.

In sorting for scab, every peach that showed a trace of the disease was counted, and these were again sorted and a count made of the peaches that were badly affected. Those that fell into the badly affected class were as a rule thoroughly spotted over one side, cracked more or less, and unmerchable. It will be observed from the table that 93 per cent of the crop on the unsprayed trees was affected with scab, and that 42 per cent of the crop was so badly diseased that it could not be marketed. On the other hand, practically none of the fruit on the sprayed trees was lost from scab, and only about 16 per cent to 21 per cent of the crop was affected at all. Nearly all of the affected fruit on the sprayed trees had only small spots of scab—mostly inconspicuous specks which did not injure its market value.

EXPERIMENT IN ILLINOIS.

At the request of and in cooperation with Mr. H. A. Aldrich, an experiment was conducted on his place at Neoga, Ill. The work was done in a 20-acre orchard consisting of apples, peaches, and cherries about 7 years old. The peaches occupied every alternate row and the cherries alternated with the apples in the other rows. The entire orchard, with the exception of three rows, was divided into 9 plots, and several different mixtures were tried, but only the lime-sulphur work will be discussed here.

This experiment was undertaken after the plans for the season's work had been made, and it had to be carried on in connection with work in Arkansas and Nebraska. The writer was therefore unable to reach the orchard for spraying the plots oftener than once a month. The principal test was made on the Elberta, although the Carman, the Waddell, the Picquet's Late, and some other varieties were included.

There were about 20 Elberta trees in each plot, and they were sprayed on May 20, June 19, and July 17. The first date was about a month after the petals dropped, and the last date a month before the crop was picked. Plot 21 was treated with self-boiled lime-

sulphur mixture consisting of 10 pounds of lime and 10 pounds of sulphur to 50 gallons of water, and plot 22 was sprayed with a weaker mixture made of 6 pounds of lime and 6 pounds of sulphur to 50 gallons of water, all prepared with cold water. The applications were made with a gasoline power sprayer, and the spray tank, which was fitted with a propeller agitator, held 250 gallons. The mixtures were made up in sufficient quantities for a tankful at each time, so that the formula for plot 21 was 50-50-250, and for plot 22 it was 30-30-250.

The dates of treatment should have been varied to suit the different varieties, but as the writer could be on the ground only at stated periods the applications were made at the right time on only the Elberta variety. The crop of 6 average trees in each plot, including the check, was picked and sorted from August 17 to August 24, and the results are shown in the following table:

TABLE II.—*Results of self-boiled lime-sulphur treatment on peach scab and brown-rot, Neoga, Ill., 1908.*

Plot.	Treatment.	Total yield.	Peaches affected with brown-rot.	Peaches affected with scab.
		Number.	Per cent.	Per cent.
21	Lime-sulphur mixture (10-10-50).....	2,757	9.0	9.6
22	Lime-sulphur mixture (6-6-50).....	2,889	12.0	18.0
23	Check—no treatment.....	2,529	35.5	100.0

The results here were about the same as those obtained in the Georgia experiment. Plot 21, which received the stronger mixture, had 9 per cent of the fruit affected with brown-rot, as compared with 35.5 per cent affected on the unsprayed trees—a saving of 26.5 per cent. The weaker mixture used on plot 22 held the brown-rot down to 12 per cent of the crop—3 per cent more than when the stronger mixture was used.

The scab results were more striking. The entire crop on the unsprayed trees was affected with the disease, every peach being more or less spotted. Most of the fruit was so badly shriveled and cracked by the disease that it was unfit for the market. On the other hand, only 9.6 per cent of the fruit sprayed with the stronger mixture was affected with scab, and none of this was bad. Most of the diseased fruits had only small spots on one side—evidently not properly reached by the spray. Commercially speaking, therefore, the disease was completely controlled. The weaker mixture used on plot 22 also controlled the disease quite well, and for commercial purposes the results were about as good as on plot 21. It is evident, however, that the 6-6-50 formula is not quite strong enough for the best results in the control of both brown-rot and scab. A strength of $7\frac{1}{2}$ or 8

pounds of sulphur and the same amount of lime would probably be about right, although a mixture of this strength has not yet been tried.

From Tables I and II it seems evident that scab may be completely controlled and brown-rot held in check to a large extent by three applications of the self-boiled lime-sulphur mixture. Mr. Aldrich says in regard to the work on his place: ^a

The fruit on the 50-50-250 part showed up almost without a blemish, and you can only realize how apt that expression is, "as pretty as a peach," when you have a crop of perfect fruit. The 30-30-250 had some scab—just a little—while the check rows were comparatively worthless; would not pay even picking expenses if they were given to you. They could not be recognized as the same varieties, although the trees stood side by side. Even if this spray was good for nothing else but the scab, no peach grower could afford to go through the season without using it.

EXPERIMENT IN ARKANSAS.

Similar experiments were conducted at Bentonville, Ark., and the results were about the same as those obtained in Georgia and Illinois, though perhaps not quite so favorable. A feature of the Arkansas work worthy of mention is the effect of the treatment on the San Jose scale. One of the orchards treated was so badly infested with this insect that at picking time the unsprayed trees were almost bare of foliage, the twigs and some of the limbs were in a dying condition, and the fruit was shriveled and worthless, due to the combined effect of the scale and the scab. Owing to the dried condition of the fruit, brown-rot did not develop to any serious extent. On the other hand, the sprayed trees which received four applications of the self-boiled wash remained in full foliage and yielded a fair crop of good merchantable fruit, the scale apparently having been held under control.

FRUIT STAINING.

An objectionable feature of the self-boiled lime-sulphur mixture is its whitewashing effect on the fruit. This is very noticeable when an application is made shortly before the fruit ripens; but if the last treatment is made about a month before picking time, the stain mostly weathers away and does not materially mar the appearance of the ripe fruit. However, it is objectionable and must be taken into consideration.

RECOMMENDATIONS FOR THE TREATMENT OF SCAB AND BROWN-ROT.

For the combined treatment of peach scab and brown-rot, at least three applications are necessary; the first, three to four weeks after the petals drop, the last about a month before the fruit ripens,

^a The Western Fruit Grower, February, 1909, pp. 52-53.

and the second midway between. Scab infections begin to take place four to six weeks after the trees bloom, and in order to control this disease the first treatment must be made not later than a month after the petals drop. The time of the last application must be determined by the ripening date of the variety. A month before the fruit ripens is about as late as it is safe to spray the trees, owing to the danger of staining the fruit, though a later treatment would often be more effective against brown-rot. Three applications distributed in this manner are sufficient for the Elberta and earlier varieties. A fourth treatment will doubtless often be desirable for later maturing varieties.

The results of the past two years' experiments are fairly good, and there seems to be no question as to the advisability of spraying the peach orchard where brown-rot and scab are troublesome, but many disappointments are naturally to be expected. The curculio and other insects readily break the skin of the peach and admit the brown-rot fungus even through a coating of the spray mixture, so that a certain amount of rot may always be expected when the conditions are favorable.

CHERRY LEAF-SPOT EXPERIMENTS.

As previously stated, cherry trees had been planted with peaches and apples in the orchard of Mr. H. A. Aldrich, at Neoga, Ill., and these were included in the experiment. Mr. Aldrich informed the writer that his cherry trees had been defoliated every year for several years and that he had practically lost two of his varieties—the Wragg and the Ostheimer. This trouble proved to be due to the cherry leaf-spot (*Cylindrosporium padi* Karst.), which is common throughout the Middle West, often causing complete defoliation of cherry trees. The English Morello has been abandoned in many sections on account of this disease.

The Montmorency, Dyehouse, Early Richmond, Wragg, and Ostheimer varieties were included in each plot of the experiment. Many trees of the last two varieties had died, and the others were mostly stunted and sickly. All the plots were sprayed on the same dates, viz, May 20, June 20, and July 17. The first date was about a month after the trees bloomed and the second immediately after the crop was picked. This application was purposely delayed to allow the fruit to ripen so as to avoid staining it. Some infections had already taken place when the first application was made, but not enough to seriously interfere with the experiment. A few leaves of the Ostheimer variety were showing numerous spots of the disease, and traces of it could be detected on all varieties.

Plot 1, consisting of 40 trees, was sprayed with self-boiled lime-sulphur mixture made of 50 pounds of lime and 50 pounds of sulphur to 250 gallons of water (10-10-50 formula).

Plot 2, containing the same number of trees as plot 1, was sprayed with self-boiled lime-sulphur mixture made of 30 pounds of sulphur and 30 pounds of lime to 250 gallons of water (6-6-50 formula).

Plot 5, consisting of 20 trees, was sprayed with a factory-boiled or concentrated lime-sulphur solution at the strength of 1 gallon of the solution to 40 gallons of water.

Plot 6, containing the same number of trees as plot 5, was sprayed with Bordeaux mixture made of 2 pounds of copper sulphate and 4 pounds of lime to 50 gallons of water.

Plot 3, consisting of 20 trees, some of each variety, was left unsprayed as a check.

A block of about 100 trees, including all varieties, designated as plot 4, was sprayed by Mr. Aldrich with a proprietary mixture, which did no more good than so much water, and this furnished an additional check.

RESULTS OF THE TREATMENT.

The trees were examined and photographs made on June 19—about a month after the date of the first application. From 75 per cent to 85 per cent of the leaves of the unsprayed trees and of the trees in plot 4 had dropped, and most of the remaining leaves were quite badly spotted. A photograph of one of these trees (Montmorency) is shown in figure 1. This was generally true of all varieties, but the Early Richmond showed less injury than the others.

Plot 1, which received the 10-10-50 self-boiled lime-sulphur mixture, showed almost perfect foliage on all varieties except the Wragg and the Ostheimer, which were in a dying condition from previous years' attacks. A close examination showed that slight infections had taken place on some of the trees, and it was surprising that these were not more extensive, owing to the occurrence of heavy rains, which had partly washed the mixture off.

Plot 2, which received the 6-6-50 self-boiled lime-sulphur mixture, showed practically as good foliage as plot 1, but it could be seen by careful examination that recent infections were rather more extensive. From casual observation the foliage appeared to be perfect, as shown in figure 2, which is a photograph of a sprayed Montmorency tree made on the same date as the one in figure 1.

Plot 5, which was sprayed with factory-boiled lime-sulphur solution (1-40), was in equally as good condition as plots 1 and 2. The foliage was almost perfect and no injury resulted from the use of the solution.

Plot 6, sprayed with 2-4-50 Bordeaux mixture, was in the same condition as plot 5. The disease had been almost entirely prevented and no injury from the use of the mixture had occurred.

A second examination was made on July 15, nearly a month after the date of the second spraying, and the relative condition of the several plots had changed very little. However, the infections that had taken place just before the second application had turned the affected leaves yellow, and a number of the trees in all the sprayed plots had a somewhat yellowish appearance on this account, from 5 to 10 per cent of the foliage being so affected. This was more pronounced on plot 2 than on any other plot and looked rather alarming, but did not prove to be at all serious. The yellow leaves soon dropped and the trees took on a normal appearance, having seemingly suffered no



FIG. 1.—Unsprayed Montmorency cherry tree defoliated by the cherry leaf-spot. Photographed June 19, 1908, Neoga, Ill.

injury. During the night of the day on which the second application was made a heavy rain of about 4 inches fell, subjecting the treatments to a very severe washing—in fact, the season was abnormally wet and both the first and second applications were followed by drenching rains.

At the time of the second examination (July 15) the check trees, including plot 4, were practically bare, and photographs of sprayed and unsprayed trees made on this date are even more striking than those shown in figures 1 and 2. The defoliated trees were beginning to put out new leaves, especially at the tips of the twigs.

Examinations made in August and September revealed very little change in the condition of the various plots. The trees of plots 1, 5, and 6 held a full crop of foliage throughout the season,^a and very little, if any, difference could be observed in these plots. The self-boiled lime-sulphur mixture (10-10-50), the factory-boiled lime-sulphur solution (1-40), and the Bordeaux mixture (2-4-50) were equally effective in controlling the cherry leaf-spot. The trees in plot 2, which were sprayed with the weak (6-6-50) self-boiled lime-sulphur mixture, held up almost as well, but the mixture was evidently rather too weak for the best results. Most of the check trees



FIG. 2.—Montmorency cherry tree sprayed with self-boiled lime-sulphur mixture for the control of leaf-spot, showing full foliage. This tree stood in the same orchard and was photographed on the same date as that shown in figure 1.

put out three or four leaves at the tips of the twigs, and a few blossoms appeared from time to time during August and September.

APPLE-SCAB EXPERIMENTS.

On account of the extremely unfavorable weather conditions the apple experiments were unsatisfactory and the results not at all conclusive. To determine the relative merits of self-boiled lime-sulphur mixture (10-10-50), factory-boiled lime-sulphur solution

^aIn a recent letter Mr. Aldrich stated that the sprayed trees held their foliage until frost.

(1-25), and Bordeaux mixture in the control of apple scab, an experiment was undertaken in a block of Winesap apples at Bentonville, Ark. The trees were sprayed when about two-thirds of the petals were down. Paris green at the rate of 6 ounces to 50 gallons was used in all the mixtures. Owing to heavy rains during the blooming period and a freeze some days later, only a few scattering fruits on each tree survived, and the experiment was therefore discontinued. However, notes made on August 5 showed that the spraying had prevented the scab to a considerable extent. Practically all the fruit on the unsprayed trees was badly scabbed, dwarfed, and cracked, while most of the fruit on the sprayed trees appeared to be either free from the disease or only slightly affected. Had the fruit been picked and sorted a large percentage of it would doubtless have shown one or more scab spots, only one application having been made.

Very little difference could be observed in the results of the treatment with the different mixtures. Bordeaux mixture appeared to rank first in efficiency, factory-boiled lime-sulphur solution second, and the self-boiled mixture third, but this was merely estimated and can not be considered accurate.

A similar experiment was conducted at Tecumseh, Nebr., on a block of very large Winesap trees. Here, again, the weather conditions were unfavorable. Rains interfered with the timely applications of the mixtures and a freeze killed a considerable percentage of the crop. The object of this experiment was to determine the relative efficiency of Bordeaux mixture, self-boiled lime-sulphur mixture, and factory-boiled lime-sulphur solution in the control of apple scab. The plots, consisting of 6 trees each, were sprayed shortly before the trees bloomed (April 18), as soon as the petals were shed (May 7), and three weeks later (May 30). For the control of the codling moth Paris green was used at the rate of 6 ounces to each 50 gallons of the mixtures, and all of the plots were sprayed again on August 3, only arsenate of lead and lime, 2 pounds each to 50 gallons of water, being used.

With the exception of one lot, which was not properly prepared, the self-boiled lime-sulphur mixture did no damage to the foliage and did not russet the fruit. In the first application of factory-boiled lime-sulphur solution a strength of 1 gallon of the solution to 20 gallons of water was used, and the young leaves were quite badly scorched. In the succeeding applications a strength of 1 to 25 was used and very little injury resulted—only a light scorching of the leaves around the margin. Bordeaux mixture russeted the fruit considerably, but produced very little leaf injury. The Winesap is not so seriously subject to spray injury as some other varieties, but the russet caused by the Bordeaux mixture was quite noticeable, while the sulphur preparations produced no perceptible injury.

The self-boiled mixture made of 10 pounds of lime and 10 pounds of sulphur to 50 gallons of water prevented the early infections of scab, but heavy rains soon washed it off and allowed late infections to take place, so that the percentage of scabby fruit at picking time was high. However, very little of the fruit was badly affected and the foliage had been almost entirely protected. This mixture almost completely controlled apple bitter-rot in an experiment conducted at Bentonville, Ark., in 1907, and in special cases it may prove to be a useful substitute for Bordeaux mixture as a summer spray for apple trees.

The commercial lime-sulphur solution, two different brands of which were used, adhered better and remained effective longer than the self-boiled mixture. It controlled the scab fully as well as the 3-3-50 and almost as well as the 4-4-50 Bordeaux mixture. On varieties subject to serious injury from applications of Bordeaux mixture, such as Ben Davis and Jonathan, commercial lime-sulphur solution might be used to good advantage and is certainly worthy of trial.

The use of arsenicals in the commercial lime-sulphur wash is an unsettled question. They are broken down by the sulphids and theoretically the combination would be exceedingly injurious to apple foliage. However, Paris green at the rate of 6 ounces to 50 gallons of the diluted solution used in these experiments apparently did no damage, but it would be somewhat risky to use the combination in extensive spraying operations until a further investigation is made. Arsenate of lead was not tested in combination with the commercial lime-sulphur solution, and an opinion as to its probable effect on the foliage when so used can not be expressed here. It was used in the self-boiled wash without injury to apple foliage, but this would not be a criterion for the prepared wash.

Dr. Charles Brooks, botanist of the New Hampshire Agricultural Experiment Station, in cooperation with the writer, conducted a similar set of experiments in that State, comparing the lime-sulphur sprays with Bordeaux mixture in the treatment of apple scab. The results were about the same as those reported in this paper. The commercial lime-sulphur solution controlled the disease fully as well as Bordeaux mixture, and the use of Paris green with it had no apparent injurious results.

Approved:

JAMES WILSON,

Secretary of Agriculture.

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